Changes in superficial and perforating vein reflux after varicose vein surgery

Lena Blomgren, MD,[a*] Gunnar Johansson, MD, PhD,[a] Agneta Dahlberg-Åkerman, MD,[b] Peter Thermaenius, MD,[b] and **David Bergqvist, MD, PhD,[c]** *Stockholm and Uppsala, Sweden*

Objectives: **This prospective duplex study was conducted to study the effect of current surgical treatment for primary varicose veins on the development of venous insufficiency ≤2 years after varicose vein surgery.**

Methods: **The patients were part of a randomized controlled study where surgery for primary varicose veins was planned from a clinical examination alone or with the addition of preoperative duplex scanning. Postoperative duplex scanning was done at 2 months and 2 years.**

Results: **Operations were done on 293 patients (343 legs), 74% of whom were women. The mean age was 47 years. In 126 legs, duplex scanning was done preoperatively, at 2 months and 2 years, and at 2 months and 2 years in 251 legs. Preoperative perforating vein incompetence (PVI) was present in 64 of 126 legs. Perforator ligation was not done on 42 of these; at 2 months, 23 of these legs (55%) had no PVI, and at 2 years, 25 legs (60%) had no PVI. Sixty-one legs had no PVI preoperatively, 5 (8%) had PVI at 2 months, and 11 (18%) had PVI at 2 years. In the group of 251 legs, reversal of PVI between 2 months and 2 years was found in 28 (41%) of 68 and was more common than new PVI, which occurred in 41 (22%) of 183 ($P = .003$). After 2 years, the number of legs without venous incompetence in which perforator surgery was not performed was 11 (26%) of 42 legs with preoperative PVI and 18 (30%) of 61 legs without preoperative PVI, ($P = .713$). After 2 years, new vessel formation was more common in the surgically obliterated saphenopopliteal junction (SPJ), 4 (40%) of 10, than in the saphenofemoral junction (SFJ), 17 (11%) of 151($P = .027$), and new incompetence in a previously normal junction was more common in the SFJ, 11 (18%) of 63, than in the SPJ, 3 (1%) of 226 ($P < .001$). Reflux in the great saphenous vein (GSV) below the knee was abolished after stripping above the knee in 17 (34%) of 50 legs at 2 months and in 22 legs (44%) after 2 years.**

Conclusions: **Varicose vein surgery induces changes in the remaining venous segments of the legs that continue for several months. In most patients, perforators and the GSV below the knee can be ignored at the primary surgery. A substantial number of recurrences in the SFJ and SPJ are unavoidable with present surgical knowledge because they stem from new vessel formation and progression of disease. (J Vasc Surg 2005;42:315-20.)**

Superficial venous surgery (SVS) is still the dominating standard treatment for varicose veins. The procedures performed—stripping of the great saphenous vein (GSV), removal of the small saphenous vein (SSV), and local phlebectomies—have not changed substantially for many years. The recurrence rates are high after SVS, and a common opinion is that many recurrences could be prevented by a more meticulous surgical technique.[1-3] Recurrences may have causes other than inadequate surgery, however. Seemingly healthy veins at surgery may develop varicosities with time, and new vessels (neovascularization) can be formed.[4-6]

SVS has profound effect on the global venous hemodynamics of the leg. Segments not specifically targeted at surgery, such as perforating veins and deep veins, may reverse their incompetence when the total venous overload of the leg is reduced.[7-9] Some groups have found persisting deep or perforator incompetence after SVS, especially in legs with more advanced venous disease.[10,11] The indication for interruption of perforators in varicose vein surgery is controversial. A suggested benefit is the prevention of recurrences.[12] Others have suggested that ligation of perforators may be unnecessary.[7]

Another controversial area is the treatment of the insufficient GSV, where the procedures performed may be high ligation only, high ligation combined with ligation of selected perforators, stripping of the whole GSV, or proximal stripping of the GSV to the knee only.[13-15] High ligation only has been shown to be inferior to high ligation with stripping of the GSV.[4,16,17] Studies have indicated that stripping of the GSV from groin to ankle may be unnecessary, as the distal part is often competent, and distal stripping carries the risk of nerve damage.[18,19] Thus, many surgeons have modified their practice of surgery for varicose veins in patients with primary varicose veins: stripping of the GSV is done solely above the knee, and insufficient perforators are not interrupted.

This clinical prospective duplex study was conducted to study changes in superficial and perforating vein reflux ≤2 years after primary varicose vein surgery. Special attention was given to segments considered crucial for the choice of surgical strategy and technique, such as the saphenofemoral and saphenopopliteal junctions (SFJ and SPJ), and to segments not attended to at surgery, such as perforating veins and remnant parts of the GSV.

From the Department of Surgery[a], and the Department of Clinical Physiology[b], Capio St. Göran's Hospital, Stockholm, and the Department of Surgery[c], University Hospital, Uppsala, Sweden.

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Correspondence: Lena Blomgren, MD, Department of Surgery, Capio St. Göran's Hospital, SE-112 81 Stockholm, Sweden (e-mail: lena.blomgren@telia.com)

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METHODS

Study design. The patients were part of a randomized controlled study where primary varicose veins were operated on with or without a preoperative duplex scan in addition to the clinical examination.[20] The study, which was approved by the ethics committee at the Karolinska Hospital, Stockholm, was done in routine clinical practice and involved 20 surgeons at different levels of experience. Clinical status was classified according to the C part of the CEAP.[21]

The surgical procedures performed were removal of the GSV or SSV, extrafascial ligation of perforators, and stab avulsions of local varicose veins. The choice of surgical procedure was at the discretion of the individual surgeon, according to his or her clinical decision.

Low-molecular-weight heparins were given selectively when risk factors for deep venous thrombosis (DVT) were present, such as an elderly patient, long operating time, and contraceptive medication.

Patients were encouraged to remove all bandages on the first postoperative day, to use below knee support stockings during the daytime for at least a month, to take brisk walks daily, and to return to work within the first week.

Duplex scanning. Duplex examinations were done postoperatively at 2 months and 2 years in routine clinical practice at the Department of Clinical Physiology, Capio St. Göran's Hospital. The examinations were performed with a color flow duplex imager (Acuson 128 and Acuson 512 Sequoia, Mountain View, Calif). An appropriate imaging transducer of 5 or 7 MHz was selected in conjunction with a 3- or 4-MHz pulsed Doppler. All examinations were performed according to a standard protocol by a vascular technologist supervised by a physician at the department.

With the patient in the supine position, the venous flow was examined in the external iliac and common femoral vein, and the presence of spontaneous flow and respiratory variations were observed. Valvular function was evaluated in the femoral, popliteal, and superficial veins of the thigh after manual distal compression with the patient upright and a slightly flexed knee. Reflux with a duration of >0.5 seconds was considered significant.[22] The veins in the lower leg, including the posterior tibial, the peroneal vein, the GSV, and the SSV, were evaluated with the patient in a sitting position. Perforating veins were considered incompetent if >3 mm with bidirectional flow.

For this analysis, the anatomic sites studied were SFJ, SPJ, GSV above the knee, GSV below the knee, SSV, perforating veins in the thigh and lower leg, and deep veins. The segments examined were classified as incompetent, obliterated, or competent. For the GSV above the knee, the GSV below the knee, and the SSV, this had to be more than half of the length of the segment. If remaining or new incompetent connections were found in a segment or site, it was termed incompetent. If no color flow was detected in an operated area, it was considered obliterated. Remnant vessels without reflux in an operated area were termed competent.

Statistical analysis. Statistical analysis was performed using Statistica version 6.0 (Statsoft). Where appropriate, χ^2 and Fisher's exact test were used for comparison of proportions. Statistical significance was accepted at $P < .05$.

RESULTS

Clinical data. Two hundred and ninety-three patients (343 legs) were operated on within the study. The mean age at surgery was 47 years (range, 20 to 76 years), 217 were women (256 legs) and 76 men (87 legs). Skin changes such as hyperpigmentation, hypostatic eczema, and pre- or postulcerative changes (CEAP 4 and 5) were present preoperatively in 51 legs (15%).

High ligation and stripping of the GSV was performed in 209 legs, of which 191 were done from the groin to just below the knee and 18 from the groin to the ankle. Removal of the SSV was done in 13 legs, extrafascial ligation of perforators in 42 legs, and local phlebectomies only in 108 legs. During follow-up, 12 legs had redo surgery consisting of stripping of the GSV in 7 legs, removal of the SSV in 2 legs, and local phlebectomies in 3 legs. Details of the surgical results have been described.[20]

Duplex ultrasound was used to examine 166 legs before surgery, 326 legs 2 months after surgery, and 257 legs after 2 years; 126 legs were examined on all three occasions and 251 legs at 2 months and 2 years. The patients lost to follow-up had declined further examinations. Those who had reoperations during follow-up were also excluded. The clinical data in the different subsets are presented in Table I.

No venous obstruction was found in any patient. None was treated for a DVT within the follow-up period, although one patient had a minor filling defect in one of the gastrocnemius veins at 2 months that was not seen at the preoperative duplex. When examined 1 month later, the defect was unchanged. One patient had a superficial thrombophlebitis in the SSV that reached the SPJ at 2 months. The patient was treated with warfarin for 3 months, and no sign of DVT was seen with duplex scanning at 2 months or 2 years.

Perforating vein incompetence. There were 103 of 126 legs where perforator interruption was not performed at surgery. Before surgery 42 of these had PVI in the calf and 61 had no PVI. Of the 42 with PVI before surgery, 36 were operated on with stripping of the GSV, 1 with removal of the SSV and 3 with local phlebectomies only. The corresponding figures for the 61 without PVI preoperatively were 44 stripping of the GSV, 3 removal of the SSV and 14 local phlebectomies only. The corresponding figures for the 61 without PVI preoperatively were stripping of the GSV in 44, removal of the SSV in three, and local phlebectomies only in 14. The distribution of venous incompetence after 2 years in the two groups is shown in Table II. The only significant difference was the prevalence of PVI in the calf.

Table I. Clinical data in different subsets of the study population

	All legs at start (%)*	*Legs where duplex was done at 2 mon + 2 yrs† (%)‡*	*pre-op + 2 mon +2 yrs (%)*
Total legs	343	251	126
Male:female	87:256	71:180	35:91
Mean age, yrs	48	48	49
CEAP class 4-5 pre-op	51 (15)	42 (17)	23 (18)
GSV stripping	209 (61)	159 (63)	96 (76)
SSV excision	13 (4)	10 (4)	7 (6)
Perforator interruption	42 (12)	37 (15)	23 (18)
Local phlebectomies only	108 (31)	71 (28)	19 (15)

GSV, Greater saphenous vein; *SSV*, small saphenous vein.
*Includes all 343 legs at the start of the study.
†Includes 251 legs that were examined with duplex scaning both at 2 months and at 2 years.
‡Includes 126 legs that were examined with duplex preoperatively, at 2 months, and at 2 years.

Table II. Comparison of prevalence of venous incompetence in different segments 2 years after varicose vein surgery in legs with and without preoperative perforating vein incompetence*

Incompetent segments after 2 yrs	*PVI pre-op (42 legs)*		*no PVI pre-op (61 legs)*		
	n	*%*	*n*	*%*	*P†*
Deep veins	2	5	0	0	.164
SFJ	3	7	9	15	.194
GSV thigh	5	12	3	5	.177
GSV calf	12	29	21	34	.532
SPJ	1	2	3	5	.460
SSV	2	5	4	7	.528
PVI thigh	2	5	1	2	.362
PVI calf	17	40	11	18	.012
None	11	26	18	30	.713

PVI, Perforating vein incompetence; *SFJ*, saphenofemoral junction; *GSV,* great saphenous vein (distal to the SFJ); *SPJ,* saphenopopliteal junction; *SSV*, short saphenous vein (distal to the SPJ).
*The 103 legs in the table were examined with duplex preoperatively, after 2 months and 2 years postoperatively, and were not operated on with perforator interruption.
†χ^2 test.

Sixty-four of the 126 legs that were examined before surgery, at 2 months and 2 years after operation had PVI in the calf preoperatively. Extrafascial ligation of the perforators was done in 22 of these 64 legs. At 2 months, 15 (68%) of 22 legs had no remaining PVI, and 13 (59%) had no PVI at 2 years. Perforator ligation was not done in 42 of 64 legs with PVI in the calf preoperatively; of these, 23 legs (55%) had no PVI at 2 months and 25 (60%) had no PVI after 2 years. The fraction of legs without PVI in the calf after 2 years was not significantly lower when perforator interruption had been done ($P = .591$).

When the prevalence of PVI in the total number of legs was compared, PVI was found in the thigh before operation in 12 (7%) of 166, 2 months after operation in nine (3%) of 326, and 2 years after in five (2%) of 265. The corresponding figures for the calf were 80 (48%) of 166, 88 (27%) of 326, and 84 (32%) of 257. The limbs with PVI at 2 months and 2 years were only partly identical (Table III). A larger proportion of legs had reversal of PVI (28/68 [41%]) in the calf during follow-up than did legs with new PVI (41/183 [22%]) (P=0.003). The difference was even larger when we analyzed 103 legs that did not undergo perforator interruption and were examined preoperatively and twice postoperatively, where 25 (60%) of 42 legs had abolished PVI in the calf and 11 (18%) of 61 legs had new PVI in the calf after 2 years ($P < .001$) (Table IV).

When the legs that underwent GSV stripping were analyzed separately, the figures were comparable, with abolished PVI in the calf in 21 (58%) of 36 legs and new PVI in eight (18%) of 44 legs ($P < .001$). Similar differences were observed for PVI in the thigh, but the numbers were too small to make a meaningful analysis.

Saphenofemoral and saphenopopliteal junctions. Of the 251 legs examined with duplex scanning at both 2 months and 2 years, 151 of the 159 legs that had been operated on with stripping of the GSV were obliterated in the SFJ at 2 months. Ten legs were operated on with removal of the SSV, and all were obliterated at the SPJ at 2 months. Ninety-two legs were operated on without GSV stripping, and 63 had normal findings in the SFJ at 2 months. Of 241 legs operated on without removal of the SSV, 226 had a normal SPJ at 2 months. A comparison of the development of the duplex findings in the legs where the SFJ and the SPJ were surgically obliterated or normal at 2 months is made in Table V. A difference between the SFJ and the SPJ was that identification of new vessels where previously obliterated was more common in SPJ ($P = .027$), and new incompetence in previously normal vessels was more common in SFJ ($P < .001$).

After 2 months, reflux remained in the SFJ in five of 159 legs that had undergone GSV stripping, of these two were incompetent at 2 years, two were obliterated and one was competent. In three of 159 legs, there were competent vessels in the SFJ at 2 months, of which two were incompetent and one obliterated after 2 years. In the 92 legs not operated on in the groin, 28 had SFJ incompetence at 2 months, of which two were competent after 2 years. In 10 legs of 241, there was reflux at 2 months in the SPJ that had not been targeted at surgery. All remained incompetent at 2 years.

Remnant great saphenous vein. Fifty-nine of the 126 legs in which all three duplex scans were completed had reflux in the GSV from the groin to the ankle according to the preoperative duplex. Fifty-six of these underwent GSV stripping; the stripping in 50 legs was from the groin to just below the knee. After 2 months, 17 (34%) of 50 legs had remaining reflux in the GSV below the knee and 22

Table III. Development of perforating vein incompetence in 251 legs examined with duplex scanning at both 2 months and 2 years

–	*2 mon*	*n**	*2 yrs*	*n**
thigh	PVI	6	PVI	2
			no PVI	4
	no PVI	245	PVI	3
			no PVI	242
Calf	PVI	68	PVI	40
			no PVI	28
	no PVI	183	PVI	41
			no PVI	142

PVI, Perforating vein incompetence.
*Number of legs.

Table IV. Development of perforating vein incompetence in the lower leg in 103 legs not subjected to perforator interruption where duplex was done preoperatively, at 2 months, and 2 years

Pre-op	*n**	*2 mon post-op*		*n**	*2 yrs post-op n*
PVI	42	PVI	19	PVI	12
				no PVI	7
		no PVI	23	PVI	5
				no PVI	18
no PVI	61	PVI	5	PVI	3
				no PVI	2
		no PVI	56	PVI	8
				no PVI	48

PVI, Perforating vein incompetence.
Abolished PVI from pre-op to 2 yrs: 7 + 18/42 = 60%; new PVI from pre-op to 2 years: 3 + 8/61 = 18% ($P < .001$)
*Number of legs.

(44%) of 50 after 2 years; thus, reflux was abolished in 28 (56%) of 50 legs after 2 years. Reflux was abolished at 2 months in 33 legs due to postoperative thrombophlebitis and occlusion in 16 and reversal of reflux in 17.

In comparison, preoperative duplex scanning did not show any reflux in the GSV below the knee in 49 legs. Thirty of these legs underwent proximal stripping of the GSV to the knee and other segments than the GSV were operated on in 19 legs. At 2 months, 2/30 and 0/19 were incompetent in the GSV below the knee, and the corresponding figures after 2 years were 6/30 and 4/19. A larger fraction of legs, 28 (56%) of 50, thus had abolished reflux in the GSV below the knee during follow-up than did legs, 10 (20%) of 49, in which new reflux developed in the GSV below the knee ($P < .001$).

Table V. Development of duplex findings in the legs where the saphenofemoral and saphenopopliteal junctions were obliterated or competent 2 months after surgery.

Duplex findings at 2 months	*n*	*Duplex findings at 2 year*	*n (%)*
SFJ obliterated	151	Incompetent	17 (11)
		Obliterated	133
		Competent	1
SFJ competent	63	Incompetent	11 (18)
		Obliterated	1
		Competent	51
SPJ obliterated	10	Incompetent	4 (40)
		Obliterated	6
		Competent	0
SPJ competent	226	Incompetent	3 (1)
		Obliterated	2
		Competent	221

SFJ, Saphenofemoral junction; *SPJ*, saphenopopliteal.

Fifteen of the 18 legs with stripping of the GSV from groin to ankle were examined again at 2 years. The pattern of incompetent segments was similar compared with the legs that underwent proximal stripping only; however, the figures for the different segments were considered too small for analysis.

DISCUSSION

The main finding in this study was that the changes induced in the venous system of the legs by current surgical practices or varicose veins were not static. A substantial number of the legs continued to improve from 2 months to 2 years after operation. This long-lasting beneficial effect of SVS was partly counteracted by the formation of new incompetent vessels in surgically obliterated sites and the progression of venous disease in previously normal vessels, recurrences that with present lack of etiologic knowledge cannot be prevented with improved surgical technique.

Surgery for primary varicose veins led to competence in perforating veins without perforator interruption. The prevalence of PVI in the calf in the whole study group was reduced from 48% to 27%, and after 2 years, there was only a slight increase to 32%.

The role of PVI is controversial. One possible indication for perforator surgery is the prevention of recurrences.[12] In this study, the legs with PVI in the calf preoperatively that was not attended to at primary surgery did not develop more incompetence after 2 years in any other segment than in the perforators itself compared with the legs without preoperative PVI. Furthermore, the fraction of legs with normal findings at 2 years was also similar in the legs with and without PVI in the calf preoperatively. Another interesting finding was that the legs with PVI were not the same at 2 months and at 2 years. When studied

prospectively, a larger fraction of legs had reversal of PVI (41%) in the calf during follow-up than did legs with new PVI (22%). Thus, interruption of perforators at primary surgery would not prevent new PVI in legs with recurrent disease.

The mechanism of the continuing beneficial effect of SVS on remaining incompetent perforating veins from 2 months to 2 years postoperatively is not known. It can be speculated that the elastic elements of the venous vessel wall need time to adapt to the reduced volume of venous blood.[23] As venous incompetence is the result of the combination of local factors in the vessel wall and an increased venous volume and pressure, it may be speculated that some individuals, where the local disease is not as advanced, may benefit more from volume-reducing surgery elsewhere and the perforating veins may contract and regain their competence, whereas in other individuals, the local changes have become irreversible. This can be observed in pregnant women, in whom varicose veins often develop because of a combination of systemic and local hormonal factors and increased venous volume and pressure. Some regain venous competence completely after delivery, and others have developed a permanent venous insufficiency.[24]

There may be other explanations than improved venous competence for the changes observed from 2 months to 2 years. The conditions when the duplex scan was performed, such as diurnal variations and change of investigator, may influence results, but a standardized protocol was used to minimize this variation. The changes in the immediate postoperative period may be partly caused by thrombophlebitis and occlusion, as was seen in some of the remnant GSV below the knee. It is, however, not probable that postoperative thrombophlebitis was a common cause for abolished PVI >2 months after surgery.

One interesting finding was that the incompetent perforating veins were not found in the same legs at 2 months and 2 years, the fraction of legs with PVI being similar. In other studies, incompetence often is presented as numbers or fractions at different time intervals, and thus, it is not possible to distinguish if the legs included are the same at the different times.[11,25]

Most of the PVI found preoperatively was abolished without perforator surgery. The few legs that underwent extrafascial ligation of perforating veins did not have a lower prevalence of PVI after 2 years than the legs with PVI that were operated without specific interruption of perforators. One reason may be that extrafascial ligation of perforators is technically difficult and therefore not always successful. Even when the location with coordinates are known from the duplex scan, the perforating veins can easily be confounded with tributaries in the area, as the perforators often run a more oblique course than the surgeon anticipates.

The SFJ and SPJ are considered crucial in varicose vein surgery. They are the major perforators between the superficial and the deep venous systems, and recurrences are technically difficult to reoperate. Incompetence in the SPJ was never reversed during follow-up in this study, and reversal in the SFJ was seen only in a few cases. The SFJ seemed to have a predilection for incompetence, as 18% of the legs with a normal SFJ before operation had developed reflux after 2 years, whereas this was the case in only 1% in the SPJ.

Neovascularization with reflux at the surgically obliterated site was seen in 11% in the SFJ and in 40% in the SPJ. The phenomenon of neovascularization has been much debated and its existence questioned. It is difficult to prove if the new vessels seen are truly new or if they are minimal branches left at primary surgery, not visible with duplex, that enlarge with time because of the combination of pressure from the deep venous system and inherent vessel wall and valve weakness.[26-29] It can be speculated that the more frequent neovascularization seen in the SPJ in the present study may be due to the latter explanation. The SFJ is easier to treat more radically at the junction than the SPJ, where many surgeons choose to minimize the surgical dissection because of the risk of nerve damage, among other things.[1]

Consistent with recent reports, many surgeons in clinical practice strip the proximal GSV to the knee even if the whole length of GSV is incompetent.[18,19] The present study seems to support this practice, as reflux in the GSV below the knee was abolished after operation in many legs, at least until 2 years. In some cases, this was because of a thrombophlebitis in the remaining GSV and in others, reversal of reflux. Diagnostic difficulties may occur, as the investigator may have mistaken saphenous branches for the GSV in some cases; however, the total venous reflux in the area of the GSV below the knee was reduced after proximal stripping only.

New reflux developed during follow-up in a substantial number of legs in the study. This may be a progression of the venous disease, but one cannot rule out that surgery itself has a negative influence on the remaining venous segments. If the venous flow is redirected after conduits such as the GSV are removed, veins with wall weakness that receive more flow postoperatively may dilate and become varicose.[23] It has also been speculated that surgery may cause neovascularization, for example, by angiogenic mediators in hematomas. This would then favor the use of new methods such as radiofrequency ablation of the GSV where there is no surgical trauma in the groin.[30] However, in a recent study, neovascularization was observed more often after radiofrequency ablation alone than when combined with high ligation.[31]

No DVT was found during follow-up in this study, although a minor filling defect, which was considered insignificant, occurred in a gastrocnemius vein in one leg. In other recent reports, the rate of DVT was 5% after SVS and 16% after radiofrequency ablation of the GSV, which so far makes SVS a better option.[6,32,33] The reason for the low prevalence of DVT in this study may be due to the small proportion of patients with advanced venous disease and also to the tradition of very early and aggressive mobilization, where patients were encouraged to take long walks daily from the day after surgery.

In conclusion, varicose vein surgery has beneficial effects on the venous system in the leg and also on the segments that were not specifically targeted at surgery, and it carries a low rate of DVT. The extent of venous incompetence found 2 months after varicose vein surgery is not static. Patients can improve their venous competence further but also develop incompetence in other segments. Specific surgery for perforators and the GSV below the knee can be omitted in most patients at the primary surgery. Superficial saphenous surgery fails to control junctional incompetence because of new vessel formation in a significant proportion of cases and does not prevent progression of disease. Prospective studies are needed to analyze the dynamics in venous reflux after treatment.

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